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(54) THE SENSING OF LIQUIDS ON SURFACES

(71) We, VICKERS LIMITED, a British Company, of Vickers House, Millbank Tower, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the detection of liquids on surfaces and more particularly, is concerned with the detection of the amount of liquid present on the surface of a lithographic printing plate.

According to one aspect of the present invention there is provided a method of determining the amount of liquid present on the surface of a lithographic printing plate, the method comprising directing radiation from a source of radiation to a detector by way of a standard medium which determines the proportion of said radiation reaching the detector to produce a first signal representing the amount of said radiation reaching said detector by way of the standard medium, directing radiation from said source at a given angle of incidence onto said surface so that the radiation is reflected by said surface to said detector to produce a second signal representing the amount of the radiation reflected from said surface, said angle being within the range in which the reflectivity of the plate is substantially independent of said angle, and making a comparison of the amounts represented by the first and second signals to obtain a measure of the reflectance of, and thus the amount of liquid present on, said surface in consequence of said reflectance for said radiation at said given angle being dependent upon the optical surface roughness which varies with surface wetness.

According to another aspect of the present invention there is provided a lithographic printing apparatus having liquid supply means for supplying liquid to the surface of a lithographic plate of the apparatus, control means for controlling the amount of liquid applied to said surface, means for directing radiation onto said surface at a given angle of incidence, and means for detecting the amount of radiation reflected by said surface in a particular direction to provide a signal which represents the reflectance, and thus the wetness, of said surface in consequence of said angle being within the range in which the reflectivity of the plate is substantially independent of said angle such that said signal is dependent upon the apparent surface roughness, which varies with surface wetness, said signal providing the data for adjusting said control means.

In one embodiment, the method of the present invention comprises:—

(i) providing a radiation sensitive device in an electrical circuit, which device is such as to produce a variation in an electrical parameter in the circuit in dependence upon the device,

(ii) directing radiation on to a standard surface so that radiation is reflected by said standard surface on to said device,

(iii) adjusting said circuit so that a first signal of predetermined level is produced by the circuit, and

(iv) directing radiation at a given angle of incidence on to said surface of the printing plate of the apparatus when wet with liquid so that radiation is reflected by the wet surface on to the device to produce in the adjusted circuit a second signal representative of the intensity of radiation reflected by the liquid and hence being a measure of the amount of liquid present on the surface.

Preferably, the radiation directed on to the wet surface is passed through a chopper so that chopped radiation is directed on to

the surface and reflected chopped radiation is directed on to the device. Thus, the circuit produces an alternating signal. The use of chopped radiation is preferred since this enables any stray light to be discriminated against and, if filters are incorporated in the chopper, distinct bands of radiation can be discriminated against.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a graph consisting of two curves showing the variation in reflectivity of water and of an anodised aluminium surface in dependence on the angle of incidence of radiation, percentage of intensity reflected being plotted as ordinate and angle of incidence (θ) being plotted as abscissa;

Figure 2 shows schematically a measuring head for sensing the reflectivity of a surface;

Figure 3 shows the circuit diagram for the measuring head shown in Figure 2;

Figure 4 shows a block diagram of a printing press including the measuring head shown in Figure 2 and also including the circuitry of an embodiment which is an alternative to that of Figure 3;

Figure 5 shows waveforms in the circuitry of Figure 4; and

Figure 6 shows in more detail a part of the circuitry of Figure 4.

Th reflectivity of any surface is a function of the angle of incidence (θ) and increases with increasing angle of incidence from a lower value at small angles of incidence to 100 percent at an angle of incidence of 90°. Curve A of Figure 1 shows the variation of the reflectivity of water with angle of incidence and this curve is typical. The reflectivity of a surface is also affected by the texture of the surface and a large amount of radiation is scattered from a rough surface. The surface of an anodised lithographic printing plate has a very fine surface roughness, somewhat akin to the effect produced by sand blasting, and hence the regular reflection from such a printing plate is considerably reduced as a result of diffuse scattering. Curve B of Figure 1 shows the variation of the reflectivity of an anodised aluminium surface with angle of incidence. If a thin film of liquid is present on the plate, this will partially fill the minute imperfections in the plate and hence the reflectivity of radiation at a suitable angle of incidence will be increased. Thus, when the imperfections in the plate are completely covered by a film of liquid, the reflectivity reaches a limiting value equal to the reflectivity associated with a liquid surface at the given angle of incidence. As the film of liquid becomes thinner, the reflectivity falls steadily until it reaches a minimum at the point where the plate surface is dry. By measuring the amount of radiation reflected by the roughened surface wet with the liquid at a given angle of incidence a measure of the amount of liquid present on the surface can be obtained and the amount of liquid on the surface can then be adjusted as desired in order to obtain optimum printing results. The thickness of the film of water on the surface of a lithographic printing plate lies within the range of the surface roughness for acceptable printing results.

An optimum angle of incidence can be chosen by plotting the reflectivity of the liquid against the angle of incidence as shown in curve A of Figure 1 and by plotting the reflectivity of the plate against angle of incidence as shown in curve B of Figure 1. It can be seen that at low angles of incidence, direct reflection from the roughened surface is virtually non-existent but that the reflectivity begins to increase at a certain angle of incidence. Once this occurs, the ratio of the reflection from the wet surface to the dry surface begins to diminish. Maximum sensitivity occurs at an angle of incidence just below the value at which the reflectivity of the anodised aluminium plate begins to increase.

Figure 2 diagrammatically shows a measuring head of an apparatus for measuring the wetness of a printing surface. The head comprises a light source 1 arranged to direct a beam of light on to a mirror 2 which reflects the light on to the printing surface 3, e.g. of an anodised aluminium printing plate of a printing cylinder. The apparatus also includes a detector 4 to receive light reflected from the printing surface 3 *via* a second mirror 5. The light from the source 1 passes through a tube 6 containing a collimating lens 7 and a lens 8 which focuses the light onto an aperture 9. The light passes from the aperture 9 through apertures 10 in a chopper disc 11 driven by an electric motor 12 so that the light is transmitted from the chopper disc at a frequency of 100 c/s. The chopped light transmitted by the disc 11 then passes through a lens 13 in a tube 14 before striking the mirror 2. Light reflected from the printing surface 3 strikes the mirror 5 and then enters the detector 4 *via* a tube 15 containing a focusing lens 16. The light source 1 is a quartz halogen 12 volt 55 watt bulb. The detector 4 may be coupled to a circuit responsive substantially only to the alternating component of the signal produced by the detector 4 to discriminate against any stray light. Moreover, filters may optionally be incorporated into the chopper disc 11 so that distinct bands of radiation can be discriminated against if desired.

The lens 13 focuses light on to the printing surface 3 to restrict the size of the light spot on the printing surface 3. This restricts the amount of scattered light which will reach the detector 4 and also defines accurately the area of the printing surface 3 being examined. The tube 15 also eliminates much of the scattered light. In this embodiment, it is important that directly reflected light, rather than diffusely scattered light, is detected by the detector 4. The mirrors 2 and 5 enable the profile presented by the apparatus to the printing surface to be kept small while still directing light on to the printing surface at an optimum angle of incidence.

A standard is also provided for the measurement, and in one case this can be achieved by reflecting light from the surface 3 when dry, thereby to obtain the response of the apparatus to a dry surface and calibration of the zero wetness response of the apparatus for that surface. Figure 2 shows how another form of standard may be provided. The standard is defined by a member 17 mounted for vertical movement, achieved by rotating about a fixed axis 18 a lever 19 pivoted to the member 17 at 20. The member 17 comprises a passage 21 to intercept the light from mirror 2 when the member 17 has been lowered. The opposite walls of the passage have glass plates 22 and 23 arranged so that light from mirror 2 will strike plate 23 twice and plate 22 once. The three reflections give a reflectivity corresponding to a certain, standard, amount of wetness. The path of the light through the passage 21 when the member 17 has been lowered is illustrated in Figure 2 by dashed lines.

One embodiment of electrical circuit for the detector 4 is shown in Figure 3. The detector in this case is a BPX 29 photo transistor 24 which effectively produces a current carrying capability which depends on the level of light striking it. The photo transistor 24 is connected in series with a 160 kilohm load resistor 25 and a 30 volt source of potential 26. A variable 10 kilohm resistor 27 is connected in parallel with the photo transistor 24 and load resistor 25 and a diode 28 is provided to electrically connect point A in the circuit between the photo transistor 24 and the load resistor 25 to the tap of the variable resistor 27. Point A is electrically connected to one input side of a bridge rectifier 29 through a 2.2 μf capacitor 30. The emitter of the photo transistor 24 is connected to the other input side of the rectifier 25 and there is a one megohm resistor 31 bridging the two input sides of the rectifier 29. The output sides of the rectifier 29 are connected to a chart recorder (not shown) *via* a 470 kilohm resistor 32, a 2.2 μf capacitor 33, and a variable one kilohm resistor 34 to tap off a suitable fraction of the output of the rectifier 29 to display the same on the chart recorder.

In use of the apparatus, light is shone from the light source 1 *via* the tube 6, chopper disc 11, lens 13 and mirror 2 so that chopped light is directed on to the dry printing surface 3 (or onto the standard device 17) at the optimum angle of incidence. The reflected chopped light is then guided to the photo transistor 24. The current carrying capability of the photo transistor 24 varies as a result of this incident light and a voltage drop across the load resistor 25 is produced. The potential at A thus varies at the chopper frequency. The variable resistor 27 is then adjusted so that for the amount of light striking the photo transistor 24 from the dry printing surface 3 (or from the standard member 17), the potential at point B is always lower than or equal to the potential at point A. In effect, A is held at the same potential as B with the result that no alternating signal is produced by the circuit. Hence the rectifier 29 produces no output with the result that nothing is recorded on the chart recorder. Having thus set up the apparatus, the apparatus is then used to detect reflected light from the printing surface when wet with the liquid (e.g. water). Because of the presence of the liquid on the printing surface 3, the amount of reflected radiation increases and hence the potential at point A drops below the potential at point B. As a result, an alternating signal is fed to the rectifier 29 at the chopper frequency. A suitable fraction of the output of the rectifier 29 is tapped off across the variable resistor 34 and displayed on the chart recorder. The output on the chart recorder is a direct measure of the amount of liquid on the printing surface 3. The information on the chart, or the signal fed thereto, will be used to control the amount of liquid fed to the printing surface 3.

An alternative arrangement is shown in block diagram form in Figure 4. Waveforms for this arrangement are shown in Figure 5.

In Figure 4, 35 denotes a printing press including a conventional printing cylinder 36 bearing an anodised aluminium printing plate having the surface 3 to monitor, and a conventional damp train roller 37 by which an amount of water can be supplied to the cylinder 36. The supply of fountain solution to the damp train roller is controlled by a motor 38. The press 35 is also provided with a measuring head 39, according to Figure 2 and also containing a preamplifier for the output of the detector, and an inductive pick-off 40 adapted to produce a pulse at a predetermined angular

position of cylinder 36. Thus, the occurrence of that pulse will coincide with the monitoring of a specific portion of the surface 3 of the cylinder 36. When the cylinder 36 is stationary, the pulse from the pick-off can be simulated by a 10 Hz multivibrator 41. A switch 42 is provided for manual selection of the output of multivibrator 41 or pick-off 40.

The pulses from switch 42 are supplied *via* a pulse shaping and limiting circuit 43 to a pulse generator 44 which is also connected to receive a signal from an amplifier 45. Amplifier 45 receives a signal of the form shown in Figure 5 at line (*a*), this signal being a representation of the light received by the detector of the measuring head. The amplifier 45 is an inverting amplifier having a variable gain determined by a variable resistance 46 and its output signal is as shown in Figure 5 at line (*b*).

The pulse generator 44 has a first output 44*a* connected to a peak-to-peak detector 47 and a second output 44*b* connected to a sample-and-hold circuit 48. The first output 44*a* delivers a signal to energise the detector 47 for approximately one cycle of the output signal of amplifier 45, when a pulse has been received from switch 42. The second output 44*b* delivers a sampling pulse (Figure 5 line *e*) near the trailing edge of the energising signal at output 44*a* to cause the sample-and-hold circuit 48 to accept and store the detected value then existing.

In fact, the detector 48 comprises a positive peak detector and a negative peak detector combined so that the negative peak detector forms the sum of the positive-going peak and the negative-going peak. The circuitry of such a detector is to be found in "Electronic Engineering" of July 1971, pages 63 and 64. Line (*c*) of Figure 5 shows the output of the positive peak detector in successive sampling intervals and line (*d*) shows the corresponding output of the negative peak detector.

The sample-and-hold circuit 48 is constructed on the basis of the circuitry shown in the magazine "Orbit", Vol. 4, No. 7, September 1969, page 58 of the English Edition published by Orbit Publishing — S.A. The output signal of circuit 48 is shown at line (*f*) of Figure 5.

The output signal of the circuit 48 is fed to two high-input, low-output, impedance unity gain buffer amplifiers 49 and 50. Means are provided to introduce a constant offset voltage to counteract the offset visible at line (*f*) of Figure 5 in the output signal of the circuit 48 so that the buffer amplifiers deliver zero voltage for the condition illustrated at the beginnings of the waveforms of Figure 5.

Buffer amplifier 49 feeds a moving-coil meter 51 to give a visual indication of the amount of wetness.

Buffer amplifier 50 feeds its output as an "actual value" to a wetness control system which may be of conventional form.

This control system has an error amplifier 52 connected to receive the "actual value" from amplifier 50 and a "desired value" from a reference voltage source 53. The output of the amplifier 52, representing the error in wetness, is supplied to a controlled rectifier motor control arrangement 54 for controlling the motor 38 in the sense tending to achieve the "desired value" of wetness.

When the device 17 is operative, the resistance 46 is adjusted to give a predetermined indication at the meter 51. When the device 17 is withdrawn, the deflections at the meter provide a measure of the surface wetness according to a scale calibrated in terms of the standard defined by device 17. Effectively, therefore, any meter deflection from the predetermined indication represents the difference between the wetness of the surface of the printing plate and the standard wetness.

Moreover, the signal supplied by amplifier 50 to the control system will be dependent on the wetness of the printing plate but not substantially on long term variations in the strength of the source 1 and the sensitivity of the detector 4 as this signal will intermittently have a reference level set by use of the device 17 and the resistance 46. The effect is of a comparison between the amounts of light reflected by the standard and by the wet surface to produce a signal substantially only dependent upon the surface wetness and with a reference level dependent upon the standard.

Figure 4 also shows a switch 55 enabling the wetness control system to be disconnected during use of the standard and enabling the values of wetness found immediately before use of the standard to be retained in the system for use when the control system is next brought into operation. For this purpose a capacitor of the circuit 48 for storing the values for amplifier 50 is connected downstream of the switch 55.

Figure 6 is a circuit diagram of the shaping circuit 43 and that of generator 44.

The shaping circuit 43 comprises limiting diodes 56 and 57 and shaping means in the form of a Schmitt trigger circuit 58. The output of the trigger circuit 58 is connected *via* a NAND gate 59, differentiating means 60 and a limiting diode 61, to an R-S bistable circuit formed of cross-coupled NAND gates 62 and 63. Gate 59 is connected to one input of the circuit 62, 63 and a NAND gate 64 is connected to the other input, the NAND gate 64 receiving the sampling pulse from a monostable circuit 65 having a period of 50μ seconds.

One output of the bistable circuit 62, 63 is connected to the J input of a J-K bistable circuit 66 having a trigger input connected to the output of a Schmitt trigger circuit 67 for shaping the pulses from amplifier 45. The output of the Schmitt trigger circuit 67 and the output 44*a* are connected by a NAND gate 68 to a monostable circuit 69 of period of 190μ seconds. Circuit 69 is connected to circuit 65 by a NAND gate 70.

In operation, a pulse from switch 42 sets the output signal of bistable circuit 62, 63 to a high level whilst a sampling pulse from monostable circuit 65 resets that output signal to a low level. This high level signal is supplied to the J input of the bistable circuit 66, which receives at its trigger input a squared form of the signal from the amplifier 45. The circuit 66 can only change its output signal at line 44*a* to a high level in response to the high level output signal from circuit 62, 63 at the negative going edge of the signal at the trigger input. It is in fact arranged for the signal on line 44*a* to go high on the first positive-going flank of the signal from the detector 4 once a pulse has been received from the switch 42. When the output signal of the trigger circuit 67 next goes high (on the next flank of the signal from the detector 4) NAND gate 68 produces a low level signal which causes the monostable circuit 69 to produce a 190μ second pulse at the end of which the sampling pulse is produced by monostable circuit 65 to reset the bistable circuits 62, 63 and 66 and thus reduce the output signal on line 44*a* to a low level.

The result is, as described above, a pulse on line 44*a*, commencing when a pulse has been passed by switch 42 and of a duration encompassing two adjacent peaks of the signal from the detector 4, and a sampling pulse on line 44*b* at the trailing edge of the pulse on line 44*a*.

The apparatus described could be adapted so as to scan the printing surface in order to compare different transverse zones i.e. different zones along the length of the printing cylinder. Alternatively the apparatus could be arranged to scan along the margins of the printing surface, instead of examining synchronously the same ink free spot once during every revolution of the printing cylinder. During printing, the lithographic printing surface contains both ink and water and the possibility arises of using the apparatus to differentiate between ink and water on the printing surfaces.

It will be appreciated that the apparatus may include extra photocells or lamps and that other mirrors or beam splitters may be interposed in the light path. Further, the apparatus may also include filters either in the chopper or fixed in the apparatus and, more particularly, the filters may be those used to effect conventional colour separations. Moreover, if desired, polarised light could be used.

In the apparatus shown in the drawings, the light directly reflected from the printing surface 3 is examined by the detector. If desired, however, the apparatus could be used to examine the light scattered by the printing surface 3 in order to obtain a similar measure of the amount of liquid present on the printing surface. In effect, this technique is the inverse of the technique used in the apparatus shown in the drawings, in that, with a large amount of dampness, substantially no light would be detected.

WHAT WE CLAIM IS:

1. A method of determining the amount of liquid present on the surface of a lithographic printing plate, the method comprising directing radiation from a source of radiation to a detector by way of a standard medium which determines the proportion of said radiation reaching the detector to produce a first signal representing the amount of said radiation reaching said detector by way of the standard medium, directing radiation from said source at a given angle of incidence onto said surface so that the radiation is reflected by said surface to said detector to produce a second signal representing the amount of the radiation reflected from said surface, said angle being within the range in which the reflectivity of the plate is substantially independent of said angle, and making a comparison of the amounts represented by the first and second signals to obtain a measure of the reflectance of, and thus the amount of liquid present on, said surface in consequence of said reflectance for said radiation at said given angle being dependent upon the optical surface roughness which varies with surface wetness.

2. A method according to claim 1, wherein the difference between the amounts represented by the first and second signals is determined.

3. A method according to claim 1, wherein the signals are compared by passing both signals through a channel having an adjustable amplification, the amplification being adjusted to provide an output signal of predetermined magnitude from the first signal, and the second signal being subjected in the channel to the adjusted level of amplification to provide a second output signal representing the wetness of the surface.

4. A method acording to claim 1, 2 or

3, wherein the radiation is reflected off the standard medium.

5. A method according to claim 4, wherein the radiation is directed at the standard medium at said given angle.

6. A method according to claim 4 or 5, wherein the standard medium is provided by a device movable into the path of radiation adjacent to the surface.

7. A method according to claim 4, 5 or 6, wherein the standard medium is provided by two surfaces providing a multiple reflection path for the radiation.

8. A method according to any one of the preceding claims, wherein a calibration measurement for zero wetness is taken using said surface when dry as a reflecting medium for said radiation.

9. A method according to any one of the preceding claims, wherein the radiation is provided as pulses of radiation.

10. A method according to any one of the preceding claims, wherein the wetness of said surface derived by the method is employed to control the amount of liquid supplied to the surface.

11. A method according to any one of the preceding claims, wherein the portion of said surface on which the radiation is incident is an ink free region and the liquid at said region is water.

12. A lithographic printing apparatus having liquid supply means for supplying liquid to the surface of a lithographic plate of the apparatus, control means for controlling the amount of liquid supplied to said surface, means for directing radiation onto said surface at a given angle of incidence, and means for detecting the amount of radiation reflected by said surface in a particular direction to provide a signal which represents the reflectance, and thus the wetness, of said surface in consequence of said angle being within the range in which the reflectivity of the plate is substantially independent of said angle such that said signal is dependent upon the apparent surface roughness, which varies with surface wetness, said signal providing the data for adjusting said control means.

13. An apparatus according to claim 12, comprising an adjustable circuit in which said signal is provided by the detecting means, said circuit being adjustable to take into acocunt a signal derived by the directing means and detecting means from a standard medium.

14. An apparatus according to claim 13, wherein said circuit has an adjusting member for setting up a reference signal level dependent upon the standard medium and the level of radiation from the directing means, so that said circuit will provide a signal representing the difference in the amounts represented by the reference signal level and by the signal derived by the detecting means from the wet surface.

15. An apparatus according to claim 13, and comprising adjusting means for adjusting the amplification of said circuit.

16. An apparatus according to any one of claims 12 to 15, and comprising a device providing a standard reflectivity which can be brought into a radiation path from the directing means to the detecting means.

17. An apparatus according to claim 16, wherein said device has two surfaces providing a multiple reflection path for the radiation.

18. An apparatus according to any one of claims 12 to 17, and having means for providing the radiation as pulses of radiation.

19. An apparatus according to claim 18, and comprising a peak-to-peak demodulator for demodulating the signal obtained from the detecting means.

20. An apparatus according to any one of claims 12 to 19, and comprising a comparator to provide a control signal for said control means, the signal from the detecting means providing an actual value for said comparator and a reference source providing a desired value for said loop.

21. An apparatus according to any one of claims 12 to 20, and which is a rotary press in which the surface is a rotating surface.

22. An apparatus according to claim 21, and comprising means for sensing the angular position of said surface and for controlling a circuit for processing the signal from the detecting means to cause said signal to be processed at a predetermined angular position of said surface.

23. An apparatus according to any one of claims 12 to 22, in combination with a lithographic printing plate, wherein the liquid supply means is water supply means and the plate is so arranged that the region of the plate onto which the radiation is

incident, during operation of the apparatus, is free of ink and wetted by the water supply means.

24. A method of determining the amount of liquid present on a surface of a lithographic printing plate substantially as hereinbefore described with reference to Figures 2 and 3 or Figures 2 and 4 to 6 of the accompanying drawings.

25. A lithographic printing apparatus with means for determining the amount of liquid present on a surface of a lithographic printing plate of the apparatus substantially as hereinbefore described with reference to Figures 2 and 3 or Figures 2 and 4 to 6 of the accompanying drawings.

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FIG. 1

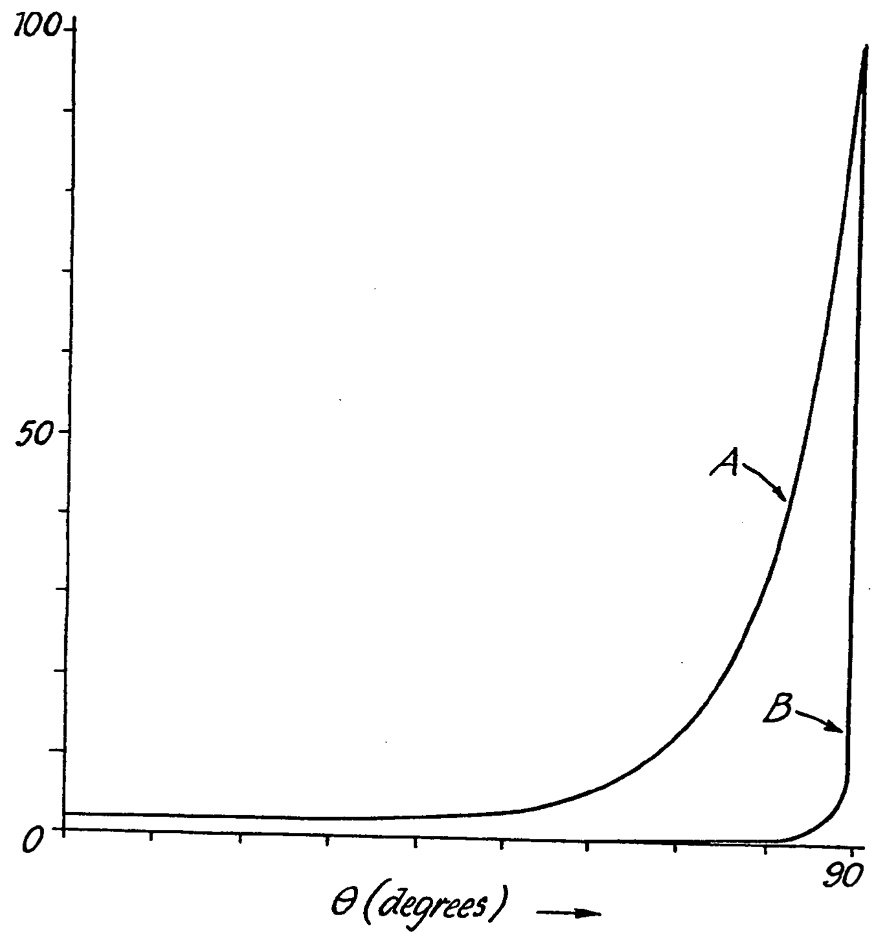


FIG.2

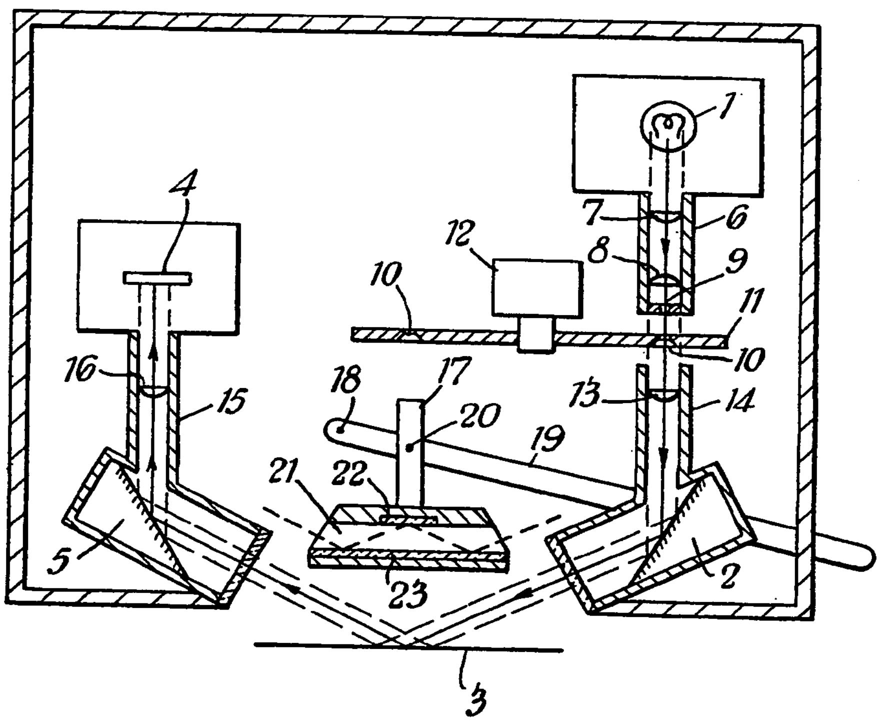
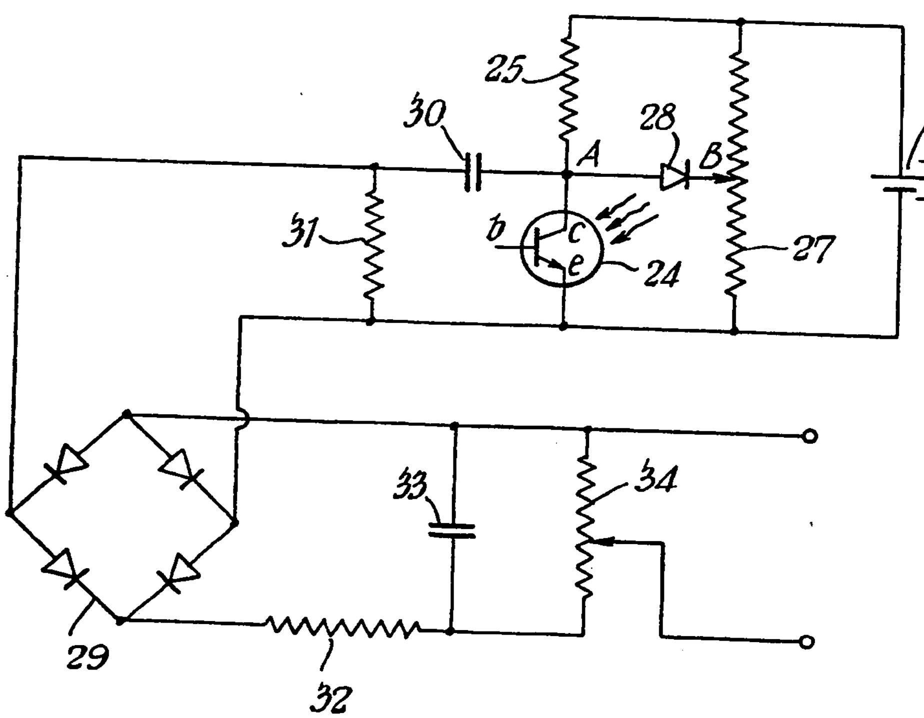


FIG.3



1,404,573 COMPLETE SPECIFICATION
6 SHEETS
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SHEET 4

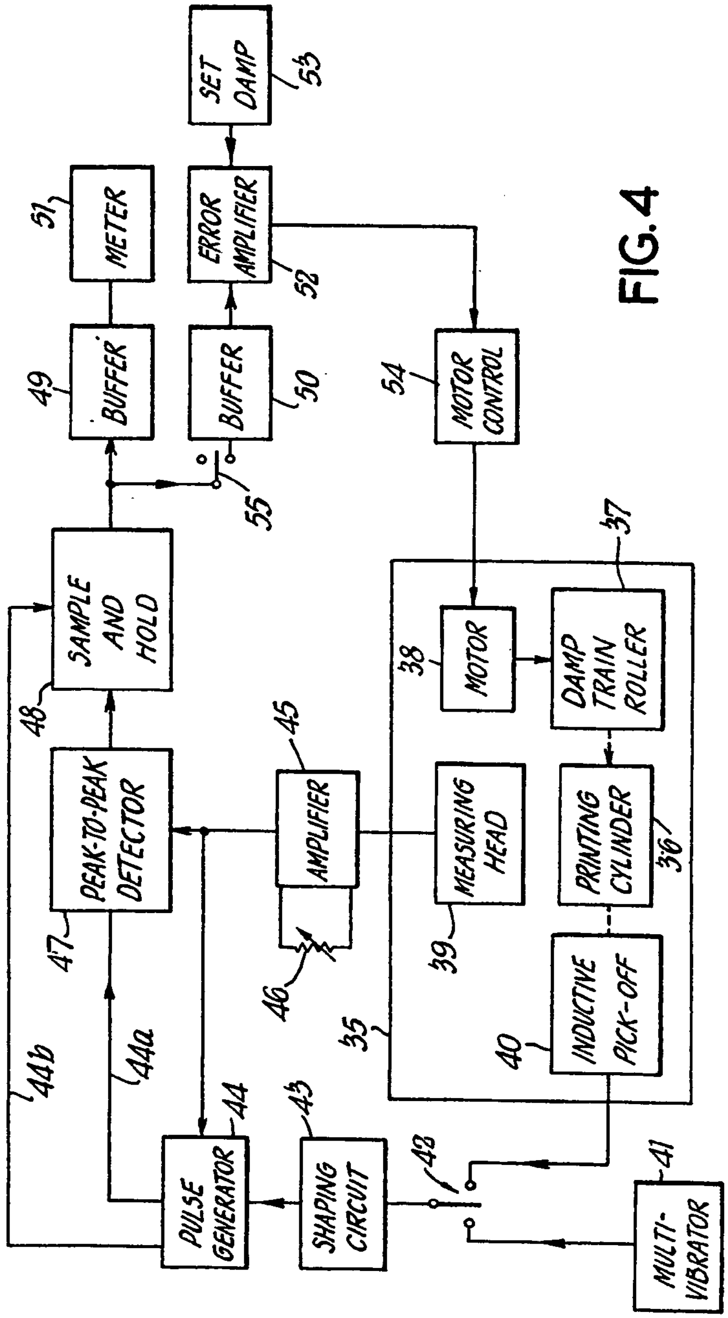
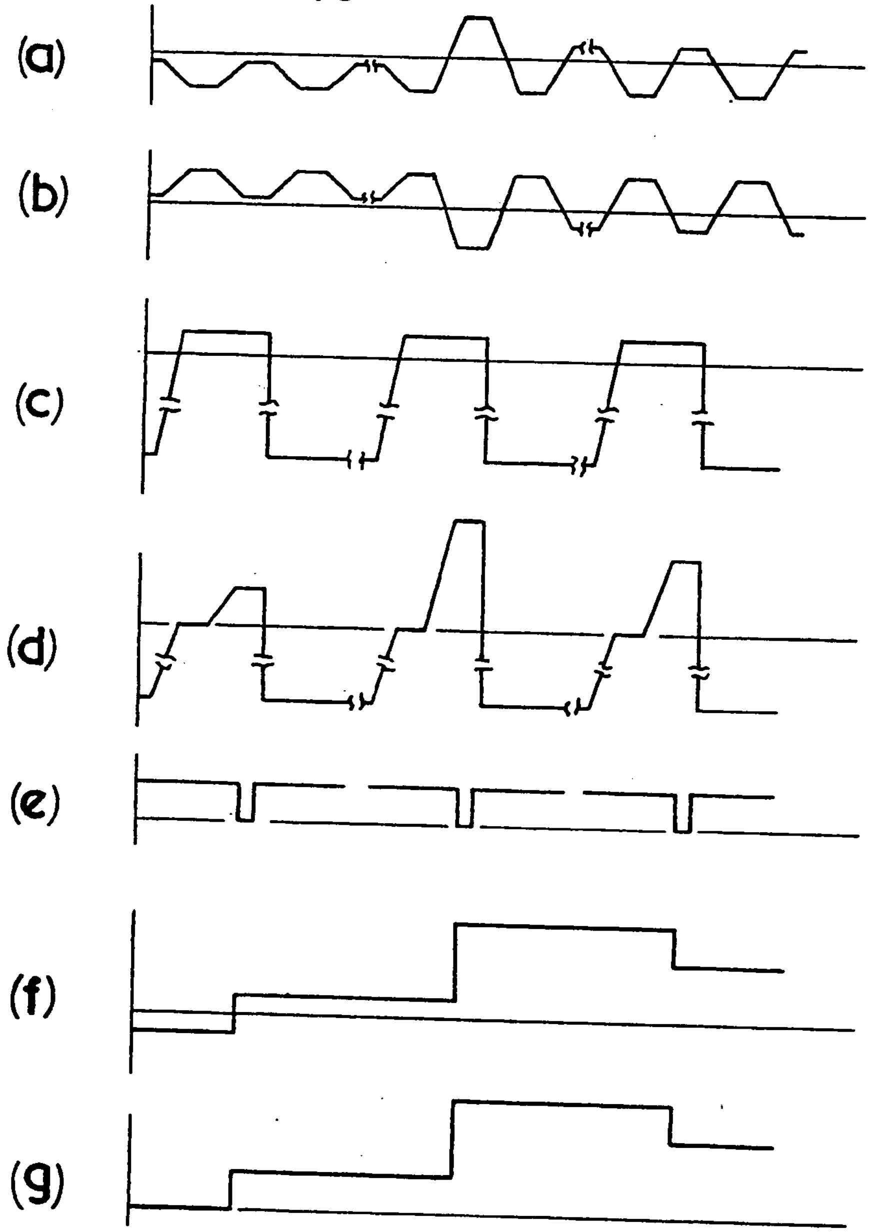


FIG. 4

FIG.5



1,404,573 COMPLETE SPECIFICATION
6 SHEETS

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SHEET 6

FIG.6